CHAPTER 4: RESULTS

4. Results

In this study, a linear measurement system of assessing the coronal interfacial microleakage in access cavities through PFM crowns restored with resin composites was used in analyzing the data. Both the mean and maximum dye penetration of the 8 interfaces of each specimen were recorded as shown in Tables 1 and 2 (Appendix D). Statistical evaluation of the results was carried out as follows:

4.1. Mean Dye Penetration from Coronal Microleakage:

4.1.1. Coronal microleakage in restored endodontic access openings (Mean Dye Penetration according to Restorative Technique, Water Storage and Thermocycling):

Table 4.1. Mean Dye Penetration for Coronal Microleakage.

Technique	Water Storage	Thermocycling	Mean	Std. Deviation	N
Packable Composite	One-day	No	0.41	.358	10
		Yes	0.93	.353	10
	Seven-day	No	0.23	.186	10
		Yes	0.52	.305	10
Packable/Flowable composite	One-day	No	0.26	.312	10
		Yes	0.80	.346	10
	Seven-day	No	0.29	.270	10
		Yes	0.34	.213	10
					80

Mean dye penetration expressed in millimeter (mm).

As seen in Table 4.1, an examination of the means and standard deviations (mm) for restorative technique, water storage and thermocycling, it was found that generally the respective mean dye penetration (mm) of all thermocycled specimens was higher than non-thermocycled specimens (only water storage). It was also noted that the mean of all thermocycled specimens after one day water storage was correspondingly higher than thermocycled specimens within seven days water storage. The greatest dye penetration was found in those specimens when thermocycling after one day water storage was carried out (Figure 4.1).

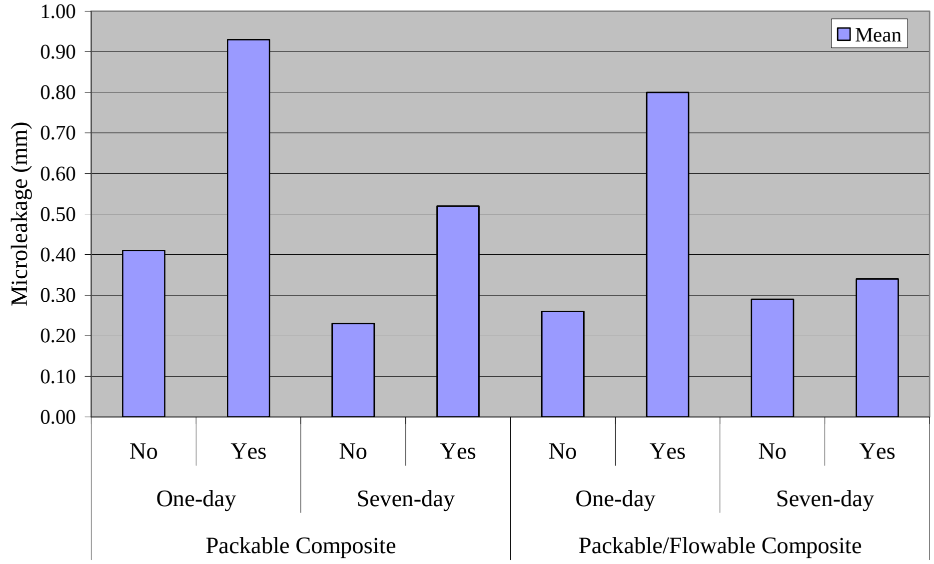

Fig. 4.1. Microleakage according to Mean Dye Penetration.

4.1.2. The Effect of Restorative Technique, Water Storage and Thermocycling on Coronal Microleakage: Mean Dye Penetration.

Three-Way ANOVA was employed to determine the effects of the restorative technique, water storage and thermocycling on coronal microleakage. Assumption of 3-way ANOVA was checked and the normality test was also checked for each factor. Each factor showed either it was normally distributed or slightly skewed positively which was in the accepted range of skewness. However, samples for each group is 40 which is more than 30, thus, Central Limit Theorem was applied. Homogeneity equality of variance was checked using Levene's test and was found that the equality of variance assumption was met (P=0.514) as shown in Table 3 (Appendix D). Thus, it can be concluded that it had not violated the homogeneity of variance assumption for 3-way ANOVA.

As seen in Table 4.2, the restorative techniques (packable composite without and packable composite with flowable liner) have no significant effect on the coronal microleakage (*P*=0.135). Only the effect of water storage and thermocycling have significant effect on the mean coronal microleakage (*P*=0.000).

However, when 2-way interaction effect between each study factor was checked, it was found that there was a significant interaction effect between thermocycling and water storage on the mean microleakage (*P*=0.009) (Table 4.2). It indicated that the effect of thermocycling on coronal microleakage may differ between one-day and seven-day water storage. Therefore, a separate analysis was done to locate the effect of thermocycling and water storage on coronal microleakage.

Table 4.2. The Effect of Restorative Technique, Water Storage and Thermocycling on Coronal Microleakage: Mean Dye Penetration.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.[a]
Restorative Technique	.201	1	.201	2.278	**.135**
Water Storage	1.308	1	1.308	14.826	**.000**
Thermocycling	2.419	1	2.419	27.411	**.000**
Water Storage * Thermocycling	.643	1	.643	7.283	**.009**

[a] Three-Way ANOVA.

4.1.3. The Effect of Water Storage and Thermocycling on Coronal Microleakage: Mean Dye Penetration.

The independent-samples t test procedure compares means for two independent variables. Ideally, for this test, the subjects should be randomly assigned to two independent variables, so that any difference in response is due to the treatment (restorative technique, thermocycling or water storage) or no difference in response due to lack of treatment) and not to other factors. The two assumptions of concern are: (1) Normality: to be checked for each independent variable using normality statistics such as skewness; and (2) Homogeneity of variance (Levene’s test).

Table 4.3. The Effect of Water Storage and Thermocycling on Coronal Microleakage: Mean Dye Penetration.

Variable: Mean Dye Penetration		N	Mean	SD	t-test for quality of Means		
					Mean differ (95% CI)	*T* statistic (*df*)[a,b]	*P* value
Thermo-cycling	No	40	.30	.286	-.348 (-.497, -.199)	-4.638 (78)[a]	**.000**
	Yes	40	.65	.378			
Water Storage	One-Day	40	.60	.430	.256 (.097, .415)	3.214 (64.402)[b]	**.002**
	Seven-Day	40	.34	.262			

[a] Equality of Variances assumed for thermocycling (Levene's test *P*-value = .097).
[b] Equality of Variance not assume for water storage (Levene's test *P*-value= .002).

As seen in Table 4.3, *p*-value of equality of variances is more than 0.05 (*P*=0.097) for thermocycling. Thus the variances are similar. Based on t-test, there is a significant difference between the mean dye penetration of non-thermocycled and thermocycled specimens.

For water storage *p*-value of equality of variances is less than 0.05 (*P*=0.002). Thus the variances are not similar. Therefore, the equality of variances was not assumed. Results indicated that there was a significant difference in dye penetration between one-day and seven-day water storage of the specimens. Mean score for the seven-day water storage was less than the mean score for one-day water storage. Thus, it was concluded that the seven-day water storage specimens had lesser coronal microleakage than the one-day water storage specimens.

4.1.4. The Effect of Water Storage on Coronal Microleakage in the Thermocycling Group: Mean Dye Penetration.

Table 4.4. The Effect of Water Storage on Coronal Microleakage in Thermocycling Group: Mean Dye Penetration.

Variable: Mean Dye Penetration		N	Mean	SD	t-test for quality of Means		
					Mean differ (95% CI)	*T* statistic (*df*)[a]	*P* value
Water Storage	One-Day	20	.86	.347	.435 (.236, .634)	4.416 (38)[a]	**.000**
	Seven-Day	20	.43	.271			

[a] Equality of Variances assumed (Levene's test *P*-value = .214).

Table 4.4 showed the effect of water storage (one-day and seven-day) to coronal microleakage in the thermocycled groups. Thermocycling showed more differences in the mean coronal microleakage for the one-day and seven-day water storage. Therefore, independent t-test was used. Then result showed there was significant differences in mean coronal microleakage between one-day and seven-day water storage specimens with thermocycling (P=0.000).

4.1.5. The Effect of Water Storage on Coronal Microleakage without Thermocycling: Mean Dye Penetration.

The normality test was checked for one-day and seven-day water storage without thermocycling and was found to be not normally distributed. Therefore, Mann-Whitney U test was employed to compare between the one-day and seven-day water storage without thermocycling. Results in Table 4.5 showed that without thermocycling there was no significant difference between the one-day and seven-day water storage.

Table 4.5. The Effect of Water Storage on Coronal Microleakage without Thermocycling: Mean Dye Penetration.

Mean Dye Penetration		N	Median (IQR)	Z stat[a]	*P* value[a]
Water Storage	One-Day	20	**0.24 (0.59)**		
	Seven-Day	20	**0.17 (0.38)**	**-.339**	**.735**
	Total	40			

[a] Mann-Whitney U Test.

4.2. Maximum Dye Penetration from Coronal Microleakage:

4.2.1. Coronal Microleakage in Restored Endodontic Access Openings (Maximum Dye Penetration according to Restorative Technique, Water Storage and Thermocycling):

Table 4.6. Maximum Dye Penetration for Coronal Microleakage.

Technique	Water Storage	Thermocycling	Mean	Std. Deviation	N
Packable Composite	One-day	No	1.30	.838	10
		Yes	2.18	.255	10
	Seven-day	No	1.06	.725	10
		Yes	1.59	.710	10
Packable/Flowable composite	One-day	No	0.82	.886	10
		Yes	1.99	.497	10
	Seven-day	No	0.89	.811	10
		Yes	1.32	.793	10
					80

Mean dye penetration expressed in millimeter (mm).

As seen in Table 4.6, an examination the means and standard deviations (mm) of maximum dye penetration (mm) for all thermocycled specimens was respectively higher than non-thermocycled specimens with corresponding duration of water storage. It was also noted that the means of all thermocycled specimens after one day water storage were higher than thermocycled specimens within seven days of water storage. The greatest dye penetration was found in those thermocycled specimens after one day water storage (Figure 4.2.).

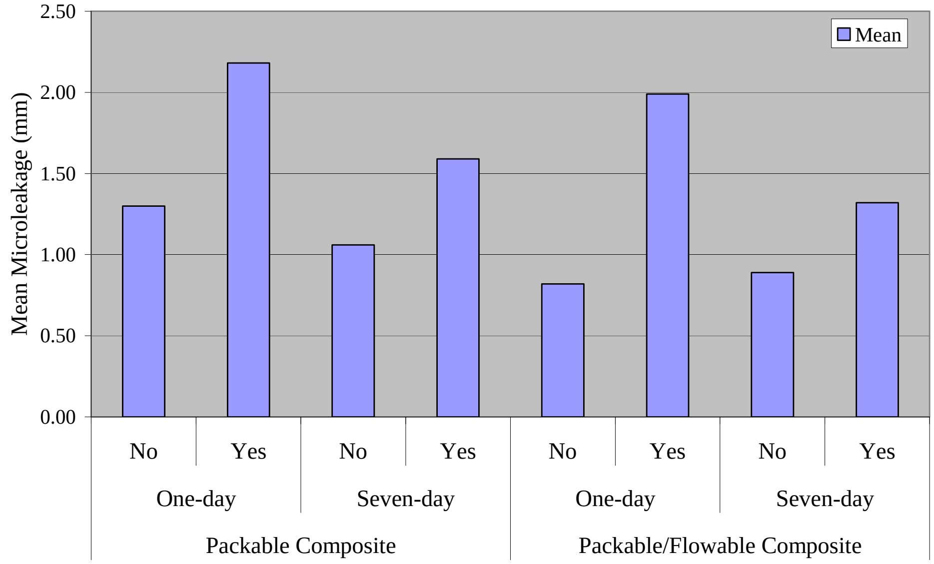

Fig. 4.2. Mean of Maximum Dye Penetration.

4.2.2. The Effect of Restorative Technique, Water Storage and Thermocycling on Coronal Microleakage: Maximum Dye Penetration.

Three-Way ANOVA was employed to obtain the effect of restorative technique, water storage and thermocycling on mean coronal microleakage. However, upon checking the assumption of normality as recommended for all data for each factor, it was found to be of non-normal distribution. Homogeneity equality of variance was checked using Levene's test and was found that equality of variance was less than .05 (P=0.001) as shown in Table 4 (Appendix D). Thus, it was concluded that it had violated assumptions for 3-way ANOVA. Transformation was rather difficult because the specimens were small and difficult to interpret especially in the 3-way ANOVA. Therefore, non-parametric test (Mann-Whitney U test) was valid and used for the maximum dye penetration.

4.2.3. The Effect of Restorative Technique on Coronal Microleakage: Maximum Dye Penetration.

Table 4.7. The Effect of Restorative Technique on Coronal Microleakage: Maximum Dye Penetration.

	Technique	N	Median (IQR)	Z stat[a]	*P* value[a]
Maximum Dye Penetration	Packable Composite	40	**1.92 (1.16)**	**-1.353**	**.176**
	Packable/Flowable composite	40	**1.47 (1.73)**		
	Total	80			

[a] Mann-Whitney U Test.

As seen in Table 4.7, there was no significant difference in maximum dye penetration between the two restorative techniques with respect to coronal microleakage (*P*=0.176). Thus, it indicated that restorative technique had no significant effect on the coronal microleakage.

4.2.4. The Effect of Water Storage on Coronal Microleakage: Maximum Dye Penetration.

Table 4.8. The Effect of Water Storage on Coronal Microleakage: Maximum Dye Penetration.

	Water Storage	N	Median (IQR)	Z stat[a]	*P* value[a]
Maximum Dye Penetration	One-day	40	**1.96 (1.44)**	**-2.157**	**.031**
	Seven-day	40	**1.32 (1.58)**		
	Total	80			

[a] Mann-Whitney U Test.

As seen in Table 4.8, there was significant difference in maximum dye penetration between one-day and seven-day water storage with respect to coronal microleakage (*P*=0.031). Median score for seven-day water storage was less than median score for one-day water storage.

4.2.5. The Effect of Thermocycling on Coronal Microleakage: Maximum Dye Penetration.

Table 4.9. The Effect of Thermocycling on Coronal Microleakage: Maximum Dye Penetration.

	Thermocycling	N	Median (IQR)	Z stat[a]	*P* value[a]
Maximum Dye Penetration	No	40	**1.00 (1.51)**	**-4.334**	**.000**
	Yes	40	**2.02 (0.54)**		
	Total	80			

[a] Mann-Whitney U Test.

As seen in Table 4.9, there was significant difference in maximum dye penetration between non-thermocycled and thermocycled specimens (*P*=0.000). Median score for thermocycled specimens was more than the median score for non-thermocycled specimens. Thus, it indicated that thermocycling had significant effect on the coronal microleakage compared to water storage only.

4.2.6. The Effect of Water Storage on Coronal Microleakage in Thermocycling Group: Maximum Dye Penetration.

Table 4.10. The Effect of Water Storage on Coronal Microleakage in Thermocycling Group: Maximum Dye Penetration.

	Water Storage	N	Median (IQR)	Z stat[a]	*P* value[a]
Maximum Dye Penetration	One-day	20	**2.13 (0.30)**	**-3.322**	**.001**
	Seven-day	20	**1.96 (1.47)**		
	Total	40			

[a] Mann-Whitney U Test.

As seen in Table 4.10, there was a significant difference in maximum dye penetration between one-day and seven-day water storage with thermocycling (*P*=0.001). Median score for seven-day water storage specimens with thermocycling was less than the median score for one-day water storage with thermocycling. Thus, it indicated that thermocycling for 500 cycles after one-day water storage had more effect than thermocycling for 504 cycles within seven-day water storage.

4.2.7. The Effect of Water Storage on Coronal Microleakage without Thermocycling: Maximum Dye Penetration.

Table 4.11. The Effect of Water Storage on Coronal Microleakage without Thermocycling: Maximum Dye Penetration.

	Water Storage	N	Median (IQR)	Z stat[a]	*P* value[a]
Maximum Dye Penetration	One-day	20	**0.94 (1.71)**	**-.339**	**.738**
	Seven-day	20	**1.00 (1.26)**		
	Total	40			

[a] Mann-Whitney U Test.

As seen in Table 4.11, there was no significant difference in maximum dye penetration between one-day and seven-day water storage specimens (*P*=0.738). Median score for seven-day non-thermocycled specimens was less than the median score for one-day non-thermocycled water storage specimens.

4.3. Comparison between Mean and Maximum Dye Penetration:

When intra-class correlation coefficient (intra-rater reliability) was calculated, there was an overall statistically significant agreement between the mean and maximum dye penetration (mm). The intra-class correlation values were high and the p-values were less than '0.001'. Thus, the two measurements were reliable as shown in Table 4.12. The intra-class correlation between the two measurements (intra-rater reliability), a measure of rater reliability, was calculated to be '0.762'.

Table 4.12. Intra-class Correlation Coefficient for Mean and Maximum Dye Penetration.

	Intra-class Correlation	95% Confidence Interval		F Test with True Value			
		Lower Bound	Upper Bound	Value	df1	df2	*P*-value
Single Measures	**.616**	**.459**	**.736**	**4.209**	**79.0**	**79**	**.000**
Average Measures	**.762**	**.630**	**.848**	**4.209**	**79.0**	**79**	**.000**

As seen in Table 4.13, there was a significant difference between the mean and maximum dye penetration ($P<0.001$).

Table 4.13. Comparison between Mean and Maximum Dye Penetration.

Variable	Mean dye penetration criteria Median (IQR)	Maximum dye penetration criteria Median (IQR)	Z stat[a]	*P* value[a]
Coronal Microleakage	**0.41 (0.59)**	**1.67 (1.58)**	**-7.525**	**<0.001**

[a] Wilcoxon signed rank test.

Whatever the evaluation criterion, sub-group B1 had 3 specimens with no leakage in any location (Figure 4.3), A1 (Figure 4.4) and A3 (Figure 4.8) sub-groups had only one specimen with no leakage in any location respectively. However, A2 (Figure 4.5), B2 (Figure 4.6), B3 (Figure 4.7), B4 (Figure 4.9) and A4 (Figure 4.10) sub-groups did not have any specimen free from dye leakage (all specimens leaked).

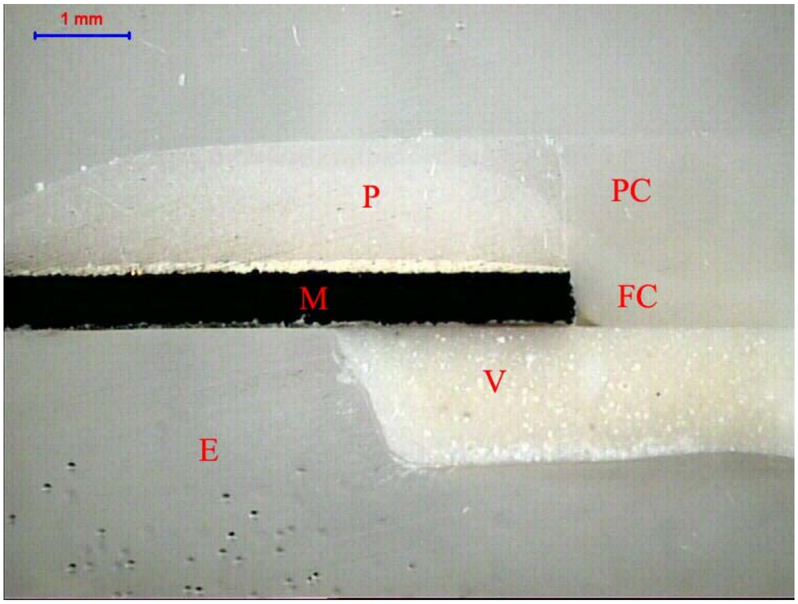

Fig. 4.3: No dye leakage at PFM-composite interface (Sub-group B1). P: Porcelain, M: Metal, PC: Packable Composite, FC: Flowable Composite, V: Vitrebond, E: Epoxy resin-mould. Blue Bar: measurement of dye extension by millimeter (1 mm).

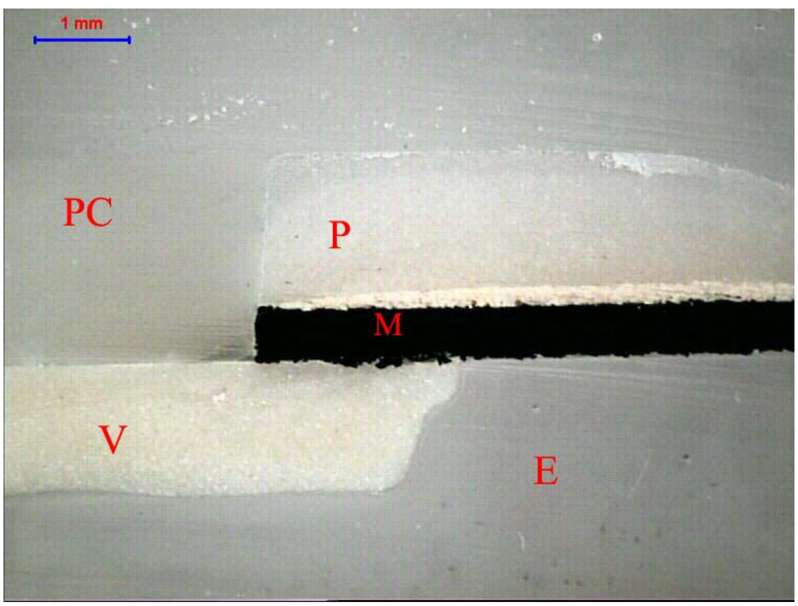

Fig. 4.4: No dye leakage at PFM-composite interface (Sub-group A1). P: Porcelain, M: Metal, PC: Packable Composite, V: Vitrebond, E: Epoxy resin-mould. Blue Bar: measurement of dye extension by millimeter (1 mm).

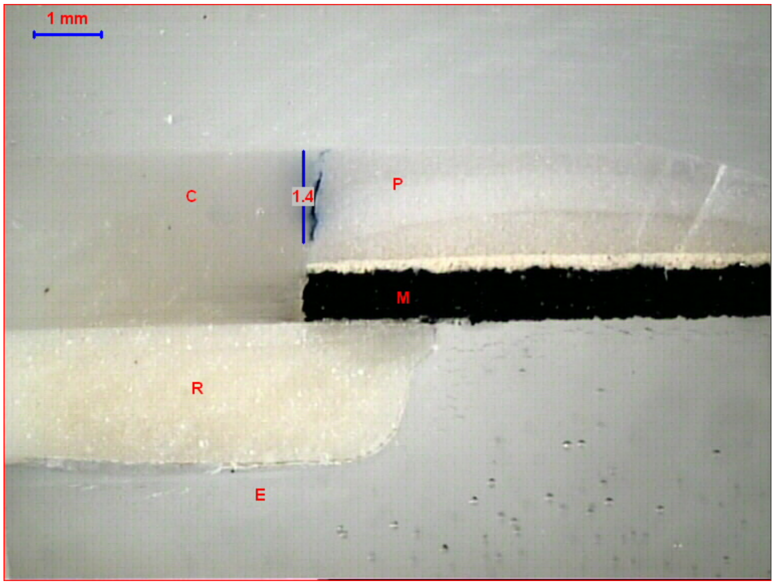

Fig. 4.5: Dye leakage at PFM-composite interface (Sub-group A2). P: Porcelain, M: Metal, C: Packable Composite, R: Vitrebond, E: Epoxy resin-mould. Blue Bar: measurement of dye extension by millimeter (1 mm).

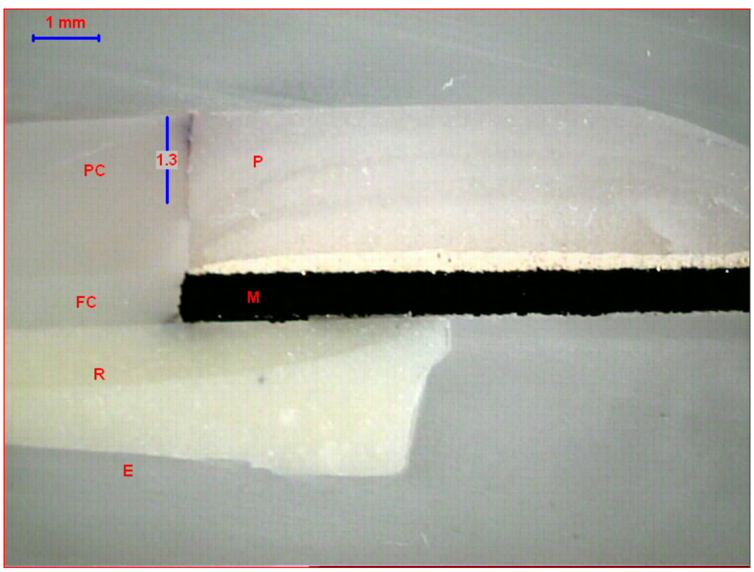

Fig. 4.6: Dye leakage at PFM-composite interface (Sub-group B2). P: Porcelain, M: Metal, PC: Packable Composite, FC: Flowable Composite, R: Vitrebond, E: Epoxy resin-mould. Blue Bar: measurement of dye extension by millimeter (1 mm).

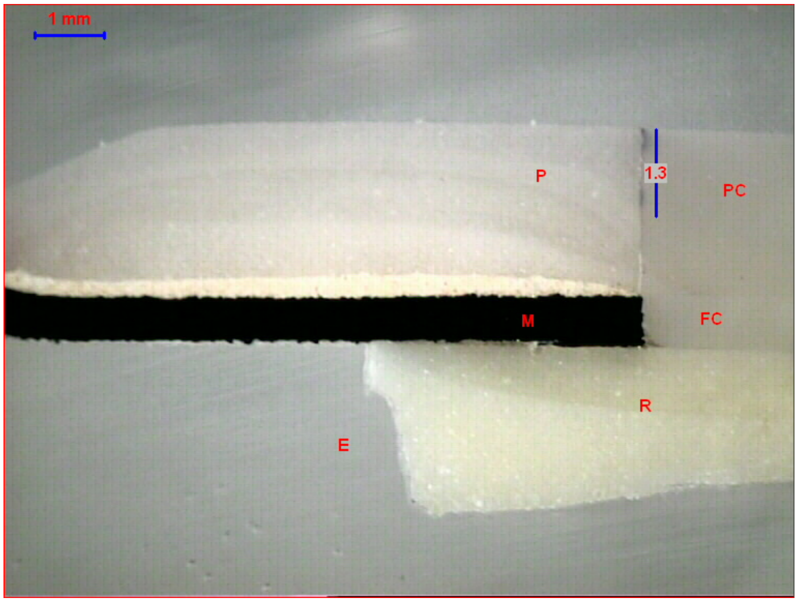

Fig. 4.7: Dye leakage at PFM-composite interface (Sub-group B3). P: Porcelain, M: Metal, PC: Packable Composite, FC: Flowable Composite, R: Vitrebond, E: Epoxy resin-mould. Blue Bar: measurement of dye extension by millimeter (1 mm).

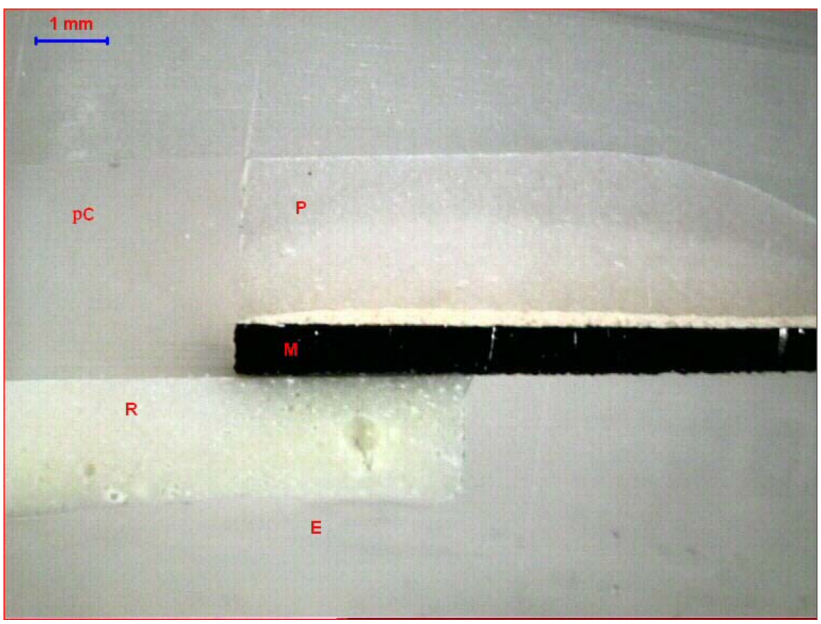

Fig. 4.8: No dye leakage at PFM-composite interface (Sub-group A3). P: Porcelain, M: Metal, PC: Packable Composite, R: Vitrebond, E: Epoxy resin-mould. Blue Bar: measurement of dye extension by millimeter (1 mm).

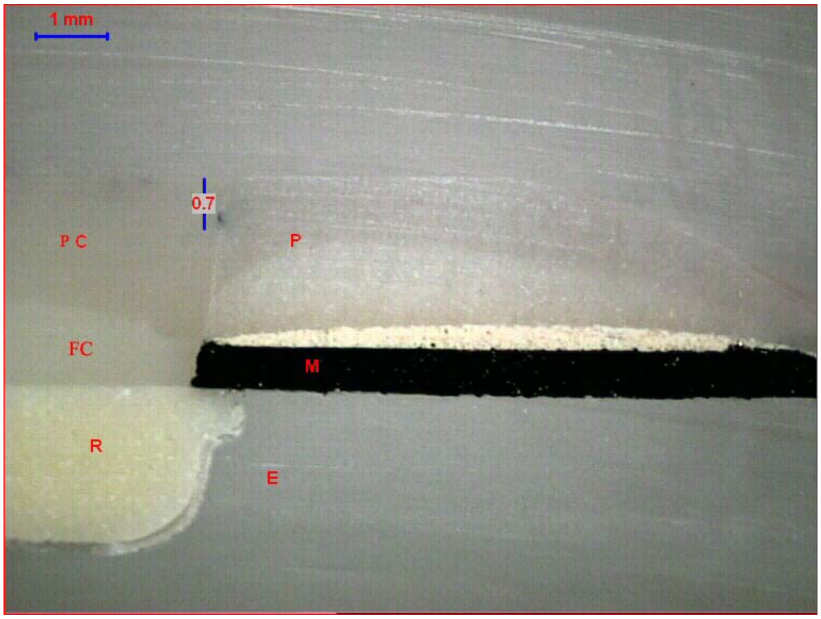

Fig. 4.9: Dye leakage at PFM-composite interface (Sub-group B4).
P: Porcelain, M: Metal, PC: Packable Composite, FC: Flowable Composite, R: Vitrebond, E: Epoxy resin-mould. Blue Bar: measurement of dye extension by millimeter (1 mm).

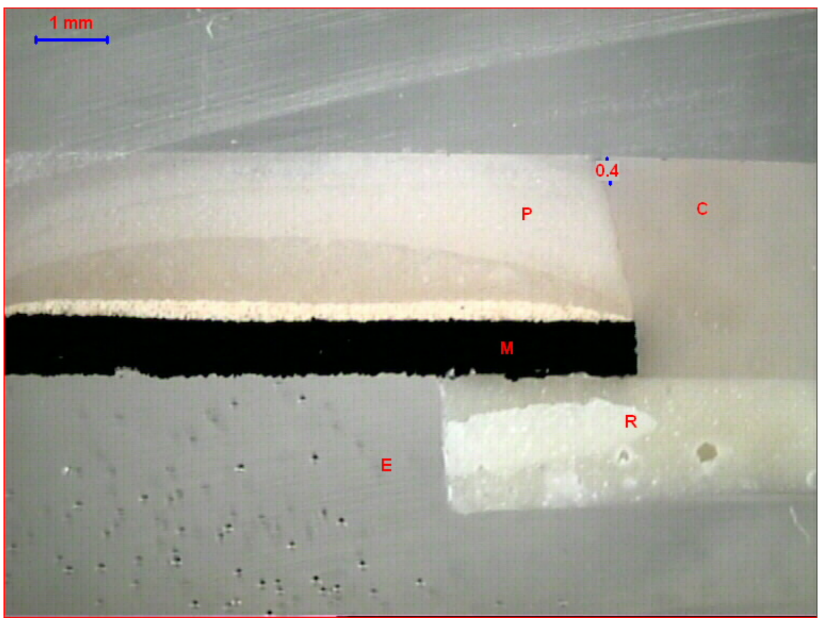

Fig. 4.10: Dye leakage at PFM-composite interface (Sub-group A4).
P: Porcelain, M: Metal, C: Packable Composite, R: Vitrebond, E: Epoxy resin-mould. Blue Bar: measurement of dye extension by millimeter (1 mm).